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THE NUTRIENT BALANCE

E. PFEIFFER

It is obvious that if one wants to follow exact, scientific soil management in farming or gardening rather than proceed by trial and error and trust to luck, one needs to know something about soil testing and about the proper NPK content of the organic materials to be used for fertilizing. While this might not be necessary in the small garden, knowledge of these things would seem to us to be a fundamental requirement if one wants to maintain the fertility of the land and if one plans to grow crops *economically*.

A lot is said about deficiency symptoms, and this is important. Yet we hear regrettably little about such questions as the wasteful or excessive use of fertilizers. A key to one vital aspect of the whole question is the fact that soils behave quite differently according to whether they have a high or low organic matter content. A borderline here is 1.5% organic matter. Below this, deficiency symptoms are more apt to show up than above this line. Furthermore, soils with a high percentage of organic matter, above 2%, have considerable natural reserves stored up in them. The problem here is to make these nutrients available, otherwise they may continue to be present but in a locked-up form.

The availability of such reserves is a function of the soil life and of the organic matter needed to feed this soil life, rather than a mere chemical equation. So the question is not so much, do I have this or that nutrient in a soil, but rather, do I make the best use of it?

This paper aims at bringing together some practical, scientific data which may aid anyone who is concerned with tackling the problems outlined above. First, some general principles of evaluation relevant to the application of organic fertilizers: The mineral fertilizer value of all fertilizers is given in terms of percent (%) of the total contents — chiefly the major elements NPK — or in terms of their availability. Calcium and magnesium are occasionally listed, as well as trace minerals.

Mineral fertilizers are described as concentrates, and the rate of application is determined accordingly.

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Organic fertilizers are something quite different. Their formula also can contain the percentage of minerals (NPK), but in limiting oneself to this one does not take into account the intrinsic values of organic matter. Especially to be kept in mind in this regard is the physical value of an organic fertilizer as a soil conditioner. We refer here both to the structural improvements brought about in soils and the increase in their content of organic life (bacteria, enzymes, growth hormones, etc.).

The late Professor Marcimpietri of the State Experimental Station of Italy, at Rome, calculated that the fertilizer value of an organic compost product is double that of its inorganic components, meaning that the combined NPK value is just about half of the entire value, expressed in money terms.

Under present conditions and currency values in the U.S.A., an organic fertilizer compost with a 2-3-5 formula would cost, f.o.b. the manufacturer, about $24 a ton, and could be sold for much more, being about half as expensive as a mineral 3-8-5.

Now we come to the question of how much to use. Let us review the mathematics of this. As is familiar to most, one calculates the percent formula in pounds per ton, and the field application in tons per acre (of the total weight of the fertilizer) keeping in mind here how many pounds per acre of any nutrient are applied.

Formula in %	*Lbs. of nutrients per ton*		
	N	P_2O_5	K_2O
1 - 1 - 1	20	20	20
2 - 2 - 2	40	40	40
2 - 3 - 5	40	60	100
2 - 4 - 5	40	80	100
1.5- 2 - 5	30	40	100
etc.	etc.	etc.	etc.

Thus one ton per acre means we are supplying the poundage of each nutrient shown in the table above, 2 tons/acre doubles each pound figure, and so on.

It has been our experience, based both on practice and experiments that the effectiveness of an organic compost fertilizer is higher than that of an inorganic fertilizer of the same formula. The behavior of the two kinds of fertilizer differs. The availability of NPK is high in the organic material, but the release is slow and steady over a long period of time. In the inorganic fertilizer there is either a very quick release and subsequently a loss, or the minerals are soon locked up in the soil and do not remain available to the plants.

Organic nitrogen lasts from 3 to 4 times as long as mineral nitrogen. When the mineral concept calls for an N=8 formula, the organic N would need to be only 2 to 3%. Considerable amounts of the phosphates and potash fertilizers get locked up in the soil. According to radioactive tracer experiments made at the U. S. Experimental Station, Beltsville, Md., 2 to 10% of the phosphate remains available. Therefore much more has to be given than is needed. This is not the case with organic compost fertilizer. The latter can be used in low formulas and is still effective. The effective ratio as between inorganic and organic nitrogen, phosphate and potash, is outlined in the following table in terms of the percentage of the total content of each which remains available to plants:

Inorganic		*Organic*	
Nitrogen	25%	Nitrogen	100%
Phosphate	10%	Phosphate	80-90%
Potash	10-15%	Potash	80-90%

A 3% organic phosphate formula will, therefore, go as far and even farther than a 15 to 18% inorganic phosphate on a pound for pound basis.

Hit or miss use of fertilizers is unnecessary. All applications can be based on the specific fertility of the soil, the requirements of the crop in question and the actual contents, in nutrients, of any given fertilizer. In other words: the entire problem can be calculated. What cannot be calculated but is left to experience and good judgment, is the holding capacity of the soil, and how much of any one nutrient the particular soil can use. This depends on the organic matter and soil life, as well as on the physical structure of the soil. Light soils need more because they hold less of what is given. Heavy soils hold more and thus need less, but the utilization factor is less too. These elements of soil behavior are definitely observable, but exact figures cannot be given as yet. An important role in this whole matter is played by the hidden reserves which do not show up in analyses of soils for available nutrients.

Organic matter in soil contains about 5% nitrogen. Therefore a soil which contains 2% organic matter (or about 40,000 pounds of it in the seven-inch top layer of an acre) theoretically has a nitrogen reserve of 2000 pounds, mostly in the form of humus and micro-organisms. Part of this reserve is made available by bacteria action. Herein lies the great value of a bacterialized compost product — to increase the bacterial action in soil.

In practice we have found (as stated at the beginning of this article) that there is a fundamental difference between soil of 1.5% organic matter and below and soils with better than 2% organic matter. The latter soils have a great capacity to utilize the nitrogen reserve, while the soils below 1.5% cannot do it. Thus the fertilizer theory and its quantitative requirements can be applied as the theory says, to such poorer soils. For the better organic soils less is needed than the theory states. This is our practical experience, and we have followed this principle quite successfully over the years. At the end of this paper we present a list of requirements and a suggestion as to how to calculate the nutrient balance. In all experiments and on field plots, this fertilizer balance should be known, and comparative tests should be made on an equal nutrient basis. Also, since it takes time to build up a soil and make the soil life work, demonstrations should be made over a period of years, and include a proper crop rotation as well.

A fundamental difference exists too with regard to soils which need building up at first and soils which are in prime condition and only need fertilizer as a means of maintenance. The maintenance rate is considerably less than the requirements of the building-up phase.

We have been speaking of such things as field plot tests. It is an obvious fact that the average farmer has neither the time nor the means available for such experiments. So, all he can do, in practice, is work along generally sound lines, and leave the accurate testing to the experiment station. Nevertheless we feel that the practical farmer should, at least, know the analysis of his fields and the contents of his fertilizer, whether inorganic or organic. By such knowledge he is protected from needless disappointments and errors.

When it comes to determining the reserves of a soil and the utilization factor, much experience is needed. It is regrettable that in the past even experimental stations have paid but little attention to this problem. The famous Liebig, father of the fertilizer theory, was well acquainted with it, and found that his theory applied well to poor soils but failed with humus-clay soils. Incidentally, the latter behaved better than the theory would indicate.

For practical purposes we operate with the following classifications: The *available minerals, Nitrogen, Phosphate,* and *Potash,* are all given in lbs./acre. Soils are listed as: *Poor Soils, Medium Soils, Good Soils.* The terms poor, medium and good

are related both to experience with regard to yield and to the soil structure — light, medium, heavy, etc.

Compost (i.e. organic fertilizers) can also be divided into groups: *Low formula*: 1-1-1 and 1-2-1. Of these, a large amount has to be given, f.i. 5 tons/acre, and if soil building is required in addition to maintenance, even more. However, these composts are especially good for legumes, and everywhere that lots of organic matter is needed. The low formulas are best for soil building. Most home-made garden composts belong in the low formula group, and manure itself, with the moisture content found in a farmyard ranks below the 1-1-1 formula. *Medium formula*: 2-2-2 and 2-3-2. One to three tons/acre may be given. *High formula*: 3-2-2, 3-3-3, 2-3-5 and higher. Of these composts 1 ton/acre or less may be given. These are especially adapted for use as booster fertilizer, as is done with high formula inorganic fertilizers used in row crops, as a side-dressing immediately before sowing, or to growing plants.

To give an example: The manufacturer of compost made from wastes can make a product with a formula of 2-3-5, as was the case in one compost made with the BD Compost Starter in Ponta Delgada, Azores.

This compost supplies:	*per ton*	*per 2 tons*	*per 3 tons*
Nitrogen	40	80	120 lbs.
Phosphates	60	120	180 lbs.
Potash	100	200	300 lbs.

The moisture content in this case was 30%. If the compost were drier, less would be needed; where the moisture content is higher, proportionately more is needed. It is evident that there is no problem with regard to the phosphate and potash supply of the Azores compost. In many cases of such compost made from wastes there will be more of these two elements than is needed. We therefore base its application on its nitrogen content.

We list, in a table below, various crops in terms of nutrients removed by each (pounds per acre). For practical reasons, however, it is found sufficient to divide the fertilizer requirements of crops into three groups:

Heavy requirements, (especially for nitrogen), of 120 to 150 lbs. per acre.

Moderate requirements, nitrogen 80 to 120 lbs. per acre.

Low requirements, nitrogen 40 to 80 lbs. per acre.

Returning to our example from the Azores to illustrate application rates:

Group I, with heavy N requirements, would need, on *poor* soils, 2 to 3 tons per acre,
on *medium* and *good* soils 1 to 2 tons would be enough.

Group II, with moderate requirements on *poor* soils would do well with 1 to 2 tons or even less.

Group III, with low requirements, would do well with 1 ton or less.

More detail as to NUTRIENTS REMOVED IN LBS. PER ACRE is given in the following table:

CROP	YIELD/ACRE	N	P_2O_5	K_2O
Potatoes	500 bu.	205	65	290
Alfalfa	4 tons	190	38	193
Mixed hay	4 tons	135	34	162
Soybean seed	30 bu.	123	33	53
Soybean hay	2.5 tons	119	30	47
Corn	50 bu.	100	48	57
Wheat	50 bu.	82	36	56
Clover hay	2 tons	82	16	65
Grass hay	2.5 tons	50	18	81
Oats	50 bu.	46	18	45
Barley	40 bu.	46	21	38

These are only a few examples.

In terms of the practical grouping (I, II, and III) of "heavy", "moderate", and "low", we can group the crops listed above as follows:

I. *Heavy requirements* from the soil are made by: sugar beets, potatoes, tomatoes, corn, tobacco, peanuts, cabbage, peppers, citrus fruits, lettuce.

II. *Moderate requirements*: carrots, many leafy garden vegetables, spinach, coffee, tea, wheat.

III. *Low requirements*: legumes, peas, beans, lupines, fava beans, oats, barley.

We have here placed all legumes under low N requirements, for most of the required nitrogen for these is not given as fertilizer but produced by bacterial action in the root nodules, provided these are present. Where there is no bacterial action and no root nodules, then the particular legume must be shifted to one of the other groups.

In a crop rotation, the main application of fertilizer is given to the group with heavy requirements; for instance potatoes, corn, sugar beets, tobacco, etc. This crop is frequently followed by wheat or others of medium and low requirements, and this second crop needs no extra gift of fertilizer (organic) on good

soils. If the second crop is followed by another of low requirements, even this will not need any additional fertilizer, provided one is dealing with a *good* soil. On *poorer* soils, one would give a *half-dose* to the second or third crop. This procedure is possible when using organic composts and manure, for they have a lasting effect and are not used up during the first few months or even years. Should crop residues or green-manuring be plowed under, the situation is even better, provided there is a suitable microlife in the soil which can take care of the digestion of the plowed-under material. The use of a low formula organic compost at the time of plowing under avoids the problem of Nitrogen being held back in the soil while the digestion process is going on.

These factors are taken into account in the nutrient balance sheet presented at the end of the article. Note in particular the listings under "Nitrogen sources in *soil*", and under "Green manuring or sods plowed under".

DEMONSTRATION PLOTS

For those so situated that they can work with demonstration plots, a few suggestions are presented. First, one might select two soil types: one *poor* and *low in nutrients*, the other *good*. Then choose a crop rotation with Group I crops and complete nutrient supply to be given; followed by Group II crops and — on good soils — no supply; finally Group III crops and either no supply or half supply. On *poor* soils one would follow the first crop with Group III crops in second place, and Group II crops in third place, and give a low formula or half of the high formula to the Group III crop.

This can be expressed as a formula in the following scheme:

Soil Type	*Crop Group*	*Tons/Acre*
good (first year)	I	2
good (second year)	II	0
good (third year)	III	1
poor (first year)	I	3
poor (second year)	III	1
poor (third year)	II	2

The best crops to use for demonstration are corn, tomatoes and tobacco from Group I; wheat from Group II; oats and any legume from Group III.

The best time for the application of a well-rotted, finished compost is 2 to 4 weeks prior to sowing.

For material that has not been treated with BD Starter, the

application should be made as many months ahead of sowing as is needed in terms of weeks for the treated compost.

Field and Plot Size. For field experiments, we prefer areas of ½ acre or more. Within these "fields", 3 to 5 areas are selected from which the crop is weighed, in order to get a balanced result. In "plot tests" a 30 x 30 foot plot is far preferable to smaller ones. There should be a distance between each plot, of at least 4 feet because of side influence, washing away, drainage, etc.

Evaluation. For evaluation of the tests, not only the yield in weight or bushel should be considered, but the bushel weight, the stand during growth and at harvest time, the analysis of the soil prior to and after the experiment, the state of health, insect pests and diseases. Of seeds harvested, the germination rate should be determined, and of feed or food crops the content in protein, minerals, trace minerals (amount and strength), and the vitamin content, at least of A and C.

We have already gone into the question of nutrients removed, in pounds per acre. In order to find the proper nutrient balance, not only the requirements of the crop under consideration should be accounted for, but one needs also to take into account the contents of the soil and its degree of fertility. Fertilizers, manures, composts, green manuring, plowed-under stubble or sods, also need to be calculated with regard to their known NPK contents.

The sum total of these natural or added supplies, subtracted from the requirement, gives the amount of any additional correction or — if one has fertilizer, manure, or compost available — tells how much of it to use.

To arrive at the nutrient balance, follow the procedures as outlined below:

NUTRIENT BALANCE SHEET *

Nitrogen Balance:

Goal in bushel of crops _____ bu. times _____ lbs. N needed, Total _____

Nitrogen sources in:

Soil light sandy — organic matter % ____ times 50 :N available ____

medium — organic matter % ____ times 25 :N available ____

heavy clay — organic matter % ____ times 20 :N available ____

Green manuring or sods plowed under:

alfalfa or ladino clover — add 75 lbs./acre ____

alfalfa-clover-grass mixture add 40 lbs./acre ____

straight grass—no N added

straw, stalks subtract 30 lbs./acre minus ____

Manure cow or barnyard ____ tons/acre times 5 N in lbs. ____

poultry ____ tons/acre times 11 N in lbs. ____

Total supplies: N lbs./acre _____

Total requirements: N lbs./acre _____

Difference either available surplus or lack of N N lbs./acre ------
Know the N content in % and lbs. of your supplement,
either manure, compost or fertilizer and use as
much as to cover the difference ------%N------lbs./ton N:------
Lbs. or tons needed therefore ----------/acre

Phosphate Balance:

Goal in bushel of crop ------ bu. times ------ lbs. P needed, Total ------
Phosphate sources in: ------
Soil use figure from analysis ------ lbs./acre
Manure cow or barnyard ------ tons/acre times 3 P per acre lbs. ------
poultry ------ tons/acre times 6 P per acre lbs. ------
or Compost % P per ton
---- lbs./ton ---- tons/acre ------ lbs. ------

Total available from sources (add) lbs. ------
Total requirements lbs. ------

Difference, either surplus or lack, to be added lbs. ------
(Know the P content of your compost and enter above.)

Potash Balance:

Goal in bushel of crop ------ bu. times ------ lbs. K needed, Total ------
Potash sources in:
Soil use figure from analysis ------ lbs./acre ------
Manure cow or barnyard ------ tons/acre times 2.5 K/acre lbs. ------
poultry ------ tons/acre times 3.0 K/acre lbs. ------
or Compost % K per ton
------ lbs./ton ------tons/acre ------ lbs. ------
(using analysis of compost or fertilizer)
Total available sources (add) lbs. ------
Total requirements lbs. ------

Difference, either surplus or lack, to be added lbs. ------
(Know the K content of your compost and enter above.)

* Author's Note: This nutrient balance sheet has been worked out by Penn State College in cooperation with the Bucks County Extension Service. We wish to give credit to this excellent work.

COMPLETE INDEX TO BE PUBLISHED SOON

BIO-DYNAMICS is happy to announce that a cumulative index, listing all the important material in Numbers One through Thirty-eight, has been prepared by Peter Escher of the Editorial Board. This work fills a long-felt need and was done in response to many requests.

The Index will be printed shortly in pamphlet form and should be available by the time our next number appears. The price will be announced at that time.

Long-term members of the Association will recall that when the matter came up at a Summer Conference several years ago, the compiler of such an index was promised a "prize" of a complete file of BIO-DYNAMICS, including the out-of-print early numbers. Our Secretary-Treasurer, Miss Speiden, is sacrificing one of the three or four remaining complete sets for this purpose. Ed. B. D.

A VEGETABLE GARDEN FROM A WOODLOT

MARY T. RICHARDS & MARJORIE SPOCK

One day, three years ago, two eurythmists set out to find a small apartment. They ended up a few minutes later with the makings of a farm: a house, a mortgage, and two acres of oak forest.

We were not completely innocent of dirt in our fingernails, as both had fitfully engaged in gardening from the first radish patches of childhood onward and had a long history of interest in Bio-Dynamics. So we looked at our expanse of forest with a speculative eye.

It was not long before we were deep in correspondence with Evelyn Speiden and the Vibbers, who came and picked out the most likely spot, a section 100 feet square, almost level, and containing the fewest mighty oaks. As the Vibbers backed out our driveway the bulldozer rolled in, and proceeded, in a two-day downpour, to lay waste the forest and our future prospects of a healthy soil as it effectively packed the saturated clay into our first mechanical hardpan. We were still too innocent to realize what a heart and back-breaking problem was being created under our very eyes. Instead we watched rejoicing in the thought that here was the beginning of our "farm."

We spent the winter picking up the smaller wood and clearing away the stones and roots. Logs from the felled trees were piled nearby in a spiral line about 5 feet high and 120 feet long, forming a stockade that was the subject of many jokes on the part of our neighbors but that turned out to be a real boon to us, for it effectively hid all the unsightly equipment we needed near the garden and later came to house our eight coldframes, tool chest and worm-culture boxes, as well as several compost piles. In the bank below it we built a root cellar.

The long winter evenings were occupied with voluminous reading of all available B. D. literature, with Bio-Dynamics our invariable bedtime story. Slowly this wealth of information was digested into a huge indexed notebook to which we could turn at a moment's notice and instantly locate any data needed. The following are some of the headings: Coldframes, Compost, Fertilizers, Fruit Trees, Monthly Calendar, Mulching, Planting Calendar, Planting Record, Plowing, Preparations, Rotation, Soil Sampling, Sprays, Symbiosis, Pruning, Storage, Herbs, Worms, Vegetable Culture Directions. Under these we have listed all articles, folders, references to material found in a host of books,

our own digests, etc. Of particular value in gardening practice has been the Monthly Calendar that has slowly emerged from our research on the best B. D. practices as these cover the seasons; it is hard to see how anyone can do without such a guide unless born to farming. We turn to it week by week to be reminded of what to do, and when and how.

Outdoors, as Spring came on, we began work on the field itself. The first soil test had resulted in the following major findings: Potassium 100; Calcium, trace; Magnesium, zero; Nitrates, 6; Ammonia, trace; Nitrites, zero; Phosphates, 75; Manganese, zero; Sulphates, zero; Organic matter, 3.8; pH, 6.0. Altogether a somewhat gloomy analysis, especially as the high organic matter findings were chiefly due to the presence of many tiny roots as yet completely undigested. Our soil was poor and sour and hard.

The plan arrived at with the help of the experts was to lime the field, give it enough quick fertilizing to get a green manure crop started, and spend the whole first year improving the soil. We put in 900 pounds of lime, 100 of bonemeal, 500 of dehydrated cow manure, and two tons of manure compost prepared during the previous Fall and Winter. Then the field was seeded to oats. In July the oats were plowed under and a soybean seeding followed. In October a mixture of vetch and rye followed the soybeans.

The March soil test showed a vast improvement: Potassium, 160; Calcium, 500; Magnesium, still zero; Nitrates, 112; Ammonia, 5; Nitrites, still zero; Phosphates, 180; Manganese, still zero; Sulphates, zero; Organic mater, 5.9; and this time traces of boron, zinc and iron. The pH was 7.0. The recommendation was to add magnesium-containing limestone and to let compost do the rest. Our soil was now ready to be used.

The plowings-under of oats, soybeans and rye had done a lot, as had these crops themselves, to improve the tilth of our land, but the hardpan just five or six inches below the surface was still such, in many places, as to convince us that we needed a subsoiling job done. So, eager to get our land in production at the earliest possible moment, we called upon a nurseryman jobber in our neighborhood to do this work, also disking and slightly levelling our rather bumpy field. He obliged about the first of April. We exulted again, only to find once more that in working the ground while still too wet he had presented us with a second mechanical hardpan even worse than the preceding one. Though

we had the disking re-done, the condition of the soil was such that we have had to do the loosening ourselves, inch by inch, with hand implements, and even to break up countless stubborn clods with our bare hands. In doing so we notice in many places, notably the lower, moister portions of the garden, that the soil had been so packed, with the last green manure crop inside the top and bottom layers, that this green matter had no chance to decompose, and the broken clods gave evidence with their fearful stench of the wrong process of decay against which B. D. literature so frequently warns. When we aerated this ground properly with hand cultivation the stench at once gave way to a pleasant earthy smell. But we believe that our bumper crop of cut worms was due to the presence of undigested green matter in the soil.

In making preparations for an early start, we had experimented with a large number of indoor plantings during February and March. Our big sunny windows bloomed with all sorts of lettuce, celery, canteloupe, watermelon, corn, squash, leek, broccoli, cabbage, cauliflower, carrot, and even artichoke seedlings, planted in pressed manure pots for ready setting-out. Of these the corn did best indoors, but the worst outdoors, while the two kinds of melons, the celery and leeks, which looked poorly indoors, have been our most luxuriant plants when once set out. In future seasons we plan to restrict indoor plantings to the three latter, since outdoor plantings at a later date provide us with equally early and much healthier crops of the other vegetables listed.

We also experimented with our first three coldframes, finding that we could keep fresh lettuce coming all winter long, even with the neglect we often meted out to these plantings. Carrots, beets and chard were planted too late in the autumn to get a winter harvest as in the case of the lettuce, but we feel certain that with earlier planting (say about the beginning of October) we can grow a winter supply of these and a few other desired root and leafy vegetables. We certainly found these frames useful in hardening off indoor plantings, and with eight at our disposal are in a good position to do some experimenting in the coming cold season. We hope, with our coldframes and a cellar full of endive (Witloof chicory) to provide ourselves with a steady supply of fresh vegetables through the winter, what with the stored root crops soon to be harvested (hurricanes permitting!)

In anticipation of saving much watering, hoeing and weed-

ing, we fell heavily for the mulch theory of gardening. Providing ourselves with a huge supply of B. D. hay and straw, we covered our field from border to border after the Spring plowing. This was a double mistake, at least in Springtime, for the rains came down and gave the hay seeds a luxuriant start while at the same time creating fungus conditions with which we have had to battle ever since. When we realized that unless we did something fast our only crop was going to be hay, we started removing the lush growth blade by blade, tweezers in hand and spectacles on nose the better to distinguish hay from leeks. Let no one tell you that mulch keeps out weeds. Hay sprouted under a cover at least four inches thick, and so did many other unwanted growths. We are against it for our clay soil on every conceivable count.

When, amid all the battling with mulch and hardpan, we got around to planting, we put in over thirty different vegetables (not counting the varieties grown to determine what kind of each vegetable we liked best and what best flourished in our soil). Besides all the common vegetables we are experimenting with artichokes and finnochio to see if these can be raised in our soil and climate. Another experiment we have in mind, following Miss Speiden's suggestions, is to grow all the hardy vegetables from seed put in the ground before the winter freeze-up.

In the lawn area around our house a considerable orchard of fruit trees (including four fig trees) has gradually been planted, and we have already begun to harvest fruits from these. Altogether we have some fourteen kinds of fruits and berries: figs, mulberries, elderberries, apples, boysenberries, red and black raspberries, nectarines, pears, peaches, and melons.

We have put a great deal of work into our little homestead, much of it easily avoidable with the proper know-how. We hope that the recital of our mistakes may save some reader-novices from falling into similar dilemmas, sparing them many an unnecessary headache and backache. But we cannot recommend too heartily the joyous practice of agriculture, for all those buoyant spirits who would test the pleasures of growing into ever deepening relationship with earth and air and sun, and have as their reward not only stronger sinews and more knowledgeable minds but the incomparable taste of B. D. produce. Speaking for ourselves, we detect besides the flavor of the good earth the savor of heaven in all we bring from our two acres to our bounteous board.

COLD WEATHER VEGETABLES*

EVELYN SPEIDEN

Diet standards vary with almost every individual, yet we all recognize the need for some fresh food not only during the growing season, but in cold weather as well. This is not the place to go into details of vitamins and food values. Actually Bio-Dynamic folk need not be concerned about this anyway. With a variety of well-grown food the vitamin problem vanishes. In general, we try to watch out for one thing—that we have food from all parts of the plant. A diet of leafy vegetables only would be one-sided; likewise one of all roots. Each part of the plant carries different values and our bodies need all three classes of food—(1) those which grow in the ground under very different conditions of light, warmth and moisture from the rest of the plant, (2) the leaves or stems, that is, the green parts of the plant which carry special effects from the sunlight, (3) the blossoms or fruit with their peculiar values. We will follow such a classification as the basis for an adequate diet—as far as vegetables are concerned. This is not to advocate nor disapprove a vegetarian diet, however.

The first summer on the Pfeiffer farm in Chester, we struggled to get a cold frame ready for use. Having a garden at all that first summer was a tremendous effort, as everyone knows who has gone through such beginnings. But by fall we had the frame, and full of young lettuce plants, mignonette and a green heading variety. We thinned and ate them as the season progressed and still had a good crop to cover over for winter, not only with glass frames but with burlap sacks of dry leaves on top and around to slow down temperature changes and keep it dark inside. Many plants will stand plenty of cold provided they freeze gradually and are kept in that state. It is frequent freezing and thawing, especially suddenly, that breaks cell walls and gives an opening for decay processes. Therefore, we let our lettuce alone all winter. In fact, we thought we had seen and eaten the last of it. But with the opening of spring it started growth again and we enjoyed beautiful lettuce weeks before anything else came from the garden. The only sad part of this tale is that we have never been able to repeat this with as much success. Unfortunately we were too busy to keep garden records, so do not know just when the plants were started. Evidently

*From a lecture given at the Bio-Dynamic Conference, July, 1955.

conditions and time were just right, the plants neither too small nor too large to winter over well, the plants suited to soil, etc., etc. However, we know it is possible to have lettuce off season—and *lettuce* is the first plant most of us think of when it comes to green food.

But there are other salad greens which have more body and flavor, so don't stop with lettuce. Raw *spinach* in salad is much more delicious than in any other form. *Cos* or *Romaine lettuce* is crisp, tender and sweet if one does not let it grow too long. There is also the *green-curled endive* and *escarole*, not bitter if grown rightly. All these do better in early spring and fall. Do not bother with them in hot weather, except to get seedlings started in time to transplant to a bed or cold frame for the fall setting out. In the garden they will last into winter with a little protection, into spring if in a cold frame. A simple way to shelter them is with chicken wire mesh bent down at the sides so it does not rest on the plants, then burlap, weeds or straw at night when frost threatens.

A small-leaved salad plant that grows even farther into the cold weather is the *corn or field salad* or lamb's lettuce (not a lettuce at all). Don't wait for its spoon-shaped leaves to grow large before using. It is good in salad mixtures. *Peppergrass cress* is another small and spicy salad material, which grows rapidly and will produce its dainty leaves under almost any conditions. It has even been grown on blotting paper, but a flat or flower pot is better. Use while small. This you can have all winter with any indoor growing place.

One of the easiest plants to grow in fall and spring or indoors in winter, and probably the most nourishing of greens is *mustard*. Though not as hot as you might expect, it still has a strong flavor, which some people consider the most delicious of any greens. As a rule it is better used in mixtures, at least until you get accustomed to it. A number of varieties are listed and you may like one better than others. Small, young leaves are excellent chopped into a mixed salad.

In the grocery store you have probably seen the delicate expensive, folded leaves they call French endive. Seed catalogues call it *Witloof chicory*. Yes, it is a close relative of the common, blue-flowered weed chicory, looks the same in bloom, grows as readily. Seed a row of it in spring, thin to at least 3 inches apart (this is important) and just let it grow. In case it throws up a seed stalk, as it may if transplanted, just cut the whole top off

leaving only enough of the crown to start again. All summer the slender leaves will be storing up nourishment in the long roots for your winter enjoyment. Before the soil freezes cut off all leaves an inch above the soil level. Bring the roots into a cool cellar, plant close together in sand and protect from all light, if necessary by covering with more sand or other material through which they can grow, for at least 6 inches. To provide a succession of leaves, control speed of growth by temperature and moisture. In several boxes you can move from cooler (even outdoors, as they endure freezing) place to warmer. Keep moist but never wet. In a few weeks you will see the tender white sprouts appear. They do better if not too warm. Cut only what you want to use at once, as they get bitter if kept. Cut just above the root as before and they will produce again. They can be left out all winter but will not grow in freezing weather, only for an early spring supply. Witloof chicory may be cooked, but it is better in salad. Slice the leaves in half inch pieces and mix with a little chopped onion or garlic and French dressing. Cultivated *dandelion* roots may be used in the same way. These are important because easily grown in any back yard and they provide raw, fresh food all winter.

Cabbage is a leafy, winter vegetable, good raw or cooked. Matured heads may be stored outdoors or in a *cool* cellar. In a dirt or sand-floored cellar, they may simply be replanted, removing loose leaves and keeping the heads well up. For outdoor storage they must be protected from freezing and thawing and from any standing water. Be sure an outdoor storage place is well drained. Leaves tend to rot under too damp conditions; some air around the heads is necessary. It seems best to leave roots on. *Savoy or crinkled cabbage* has the most delicious flavor. *Red cabbage* gives variety. *Chinese or celery cabbage* keeps well and is fine for salads. Use the heart for salad, the outer leaves for greens. This cabbage does not grow in hot weather. Plant in July directly in the row and *thin* to a foot apart—eventually. It does not transplant well. *Collards* belong to the cabbage family and are much grown in the south, producing greens there all winter. Although they do well also in the north, steady freezing temperatures are too much for them. Flavor is better after frost and a few plants give variety late in the season. Growth and size are much like broccoli and side leaves are picked, leaving the growing tip undisturbed.

To enjoy early spring vegetables from our garden, we must have made preparation the fall or summer before, usually with biennials. These make root and leafy growth one year, send up seed stalks the next—as with carrots, beets, chicory, turnips, collards, leeks and many others. Unless we decide to save our own seed, we seldom see their flowering and fruiting stages. *Kale* is a biennial and a particularly valuable plant for nutrition and decoration. If you are one of those who turn up your nose at kale, perhaps you've never grown your own. With the midrib taken out, the leaves coarsely chopped, wilted in bacon fat, then cooked with a little *water* added, it is delicious. Start the plants in early spring and transplant to at least 10 inches apart. By fall you can use the lower leaves, leaving the tip to provide early spring greens. Flavor is better after frost, but it is also good earlier. Some kinds need winter protection in the north to survive in good condition. The less curly kinds are easier to wash. *Variegated kale* and *asparagus kale* are good varieties.

A perennial much used in England is *seakale*. A handsome plant, it belongs to the cabbage family, somewhat resembles kale in its blue-green foliage, but is much larger. Shoots are cut for food in early spring. Later the flower buds may be used like broccoli. Once established, the plants will produce for years if not cut too heavily. It can also be forced like rhubarb. Liberty Hyde Bailey says of it, "The plant is little known in North America, but it is worthy of general cultivation in the home garden, for it supplies an esculent of good quality at a season when vegetables are scarce." Alas, this is the only cultivated plant described here which cannot be found in American seed catalogues, as far as I know.

Wild plants are good additions to an early spring diet, *dandelion greens* being especially appreciated because they come so early. They should be used as soon as leaves reach full size but before flower buds appear. *Lambs quarters* coming later can be used until plants are 6 to 10 inches high, stem and all. Outstanding for nutrition are the *stinging nettle's* growing tips of about the same size. Cooked like spinach or used in soup, they lose their sting and are particularly rich in iron. Better use gloves in picking. *Pokeweed* shoots are usable up to 4 to 6 inches, but not after flower buds appear. Roots are poisonous and berries not edible. Young leaves are especially good cooked Chinese style, with a little chopped fresh pork. Fry the pork until nearly done, then add the washed and cut up leaves and

mix. When leaves have wilted add a little water, salt and soy sauce, pepper and a very little sugar or honey and cook until done. Serve on rice. You may know or will discover many other wild plants.

Asparagus should come in this group and is a boon to both cook and gardener, coming so early and requiring so little annual care when once established.

Celery is a fall and winter vegetable which needs an early spring start. It is not difficult to grow but seeds are slow to germinate and plants very tiny and slow-growing, requiring transplanting while small and again later to the garden row. Mature plants may be left out in winter if well protected, or brought into a cool cellar. Avoid too much moisture, especially on leaves and stems as this will cause rotting.

Celeriac belongs rather to the root group although its leaves are good for flavoring. Called root celery, it has the same seasonal and growth rhythm as celery. Many people consider it much more delicious. Its turnip-sized knob at the root is easily stored over winter. With a nut-like flavor, it may be eaten raw, cubed, boiled and served like celery or in soups. The *leek* is its best companion plant, both being biennials, tiny plants at the start, requiring the same transplantings and doing especially well with composted pig manure. Heap the soil up around leeks and they can stay out all winter, but any left in spring should be used promptly before they go to seed.

Ordinary onions are not hardy like leeks. Only the *multiplier or potato onion* may be left out in winter. This and *garlic* may stay in the ground indefinitely and will multiply. Still another onion species, *shallots*, have "bulbs that break up into distinct bulblets that cohere at the base" (Bailey). They are quick-growing and should be harvested as soon as the leaves wilt. They store well and are said to be "milder and more aromatic than the onion" (Encyclopedia of Cookery). Leaves of shallots and the grass-like *chives* are salad material. Chives are most easily propagated by separation of the bulbs when the clump gets too large and thick. For a winter supply, do this in midsummer and start new clumps in pots or boxes. One can hardly have too many chives for their lavender blossoms are an addition also to the flower garden border.

The common onion has long been grown in the garden from sets. In the last few years *onion plants* have appeared in most catalogues and they are a great improvement. Not only can one

get more different kinds of onions, but larger and better-keeping ones. Most of these members of the genus Allium have an ancient and honorable history of association with man. Builders of the pyramids were paid in leeks and garlic; the riders of Genghis Khan carried garlic over the north in their saddle bags; shallots were named from Ascalon (Allium ascalonicum) when they were introduced into Europe from Syria (and probably from Asia) by the Crusading Knights of France. Still today they are all exceedingly valuable foods and if grown Bio-Dynamically are less apt to cause digestive difficulty. Try it and see.

Late potatoes are those for winter use. Use *beet* and *carrot* varieties suited to storage. Make midsummer seedings of *turnips* and *winter radishes.* The latter are quite different from the little radishes of spring. They are big fellows, some round, some long, with white, rose-colored, scarlet or black skins and crisp flesh eaten raw or cooked, the part just under the skin being antiscorbutic. Stored well, they keep well until spring comes again.

Parsnip, salsify (oyster plant) and *scorzonera* are root vegetables grown in much the same way—with spring planting, thinning and harvesting from late fall until spring. Parsnip (biennial) is of the parsley family and tastes better after frost. Salsify (biennial) and scorzonera (perennial) are closely related to dandelion, both having edible leaves as well as long tap roots. Scorzonera is called black salsify because of its black skin. It should be better known because it is more delicious than salsify and just as easy to grow and store.

Jerusalem artichoke, a perennial and in no way connected with globe artichoke, bears tubers on and at the end of underground rootstocks. The tubers look and taste somewhat like potatoes, but are good raw in salads as well as cooked, an excellent and prolific source of food. Plant tubers in early spring and harvest in late fall, except what may stay in the ground where they keep best.

The storage of all these root vegetables is simple. The onion family need a fairly dry and airy place, not warm but free of frost. Onions do well suspended in a cool cellar in the mesh bags in which one often buys oranges. All the others do best lying on their sides in dry sand in a *cool* place. On a dirt-floored cellar one can make sand bins with cinder blocks just laid in place and varied to suit the need. Before burying, spray the roots with

Bio-Dynamic spray 501 in a fine mist spray just as this is used in the garden. This much improves their keeping qualities.

Plants of the third group of which flowering or fruiting parts are eaten, include an array of *squashes* rather bewildering to the beginner. In general summer squashes are those raised for immediate use. The ones which will store well are called the winter squashes. Of the latter those of immense size may be good for a large family but the smaller *butternut* and *buttercup* are unexcelled for flavor and keeping quality. Butternut is more resistant to pests and more productive, ripens earlier and is edible skin and all except for the small cavity of seeds at one end. Flesh of both is thick, dry, smooth and of a bright orange color. Buttercup probably freezes better. With only a few hills of each one can have a beautiful collection of fruit—provided they are fenced well enough to keep out woodchucks. Under right conditions they will keep until the next year's crop ripens. If too warm they shrivel, if too damp they mold. Keep in a cool (but not freezing), dry place and turn them over occasionally. Don't wait for cool weather to harvest all the squash, but cut them individually when change of color and stem condition indicate maturity. Size is no indication of ripeness. And be sure to *cut* with some of the stem left on the fruit, as if it is broken off at the base, the squash will not keep.

Sweet or bell peppers keep well but may also be dried or frozen (without blanching). It is worthwhile to make the effort to get these plants started early indoors for with a longer season you can get more really ripe fruit. Green peppers are not ripe. If you leave them on the bush until they turn bright red they do not become hot, as some folks imagine, but more mild and sweeter, better flavored, more easily digested and have double the vitamin C content. Also the color is an attractive addition to many winter dishes. Hot peppers come from different plants and there are many varieties of both sweet and *hot peppers*. Just make sure you get the kind you want. If you buy plants, it is worthwhile to get one of a hot variety—one with small fruit so there is no danger of mixing—and to put the ripe fruits whole into a small jar and cover with vinegar. A drop or two of this is good on meat dishes and it keeps indefinitely.

If you have not raised *broccoli* and *purple cauliflower*, they are worthwhile as late fall food. Plants pick up after the fall rains and produce increasingly until long after frost. Their care,

size and kind of growth are much the same, and if you can freeze them, they taste especially good in winter. The purple cauliflower is beautiful in color (lovely enough for a floral centerpiece on the dinner table) and turns green on cooking. Although it grows like broccoli, it has the cauliflower flavor.

Edible-podded or *sugar peas* are picked just as the peas begin to form and prepared like snap beans. Out of 6 varieties tried, Dwarf Gray Sugar was best, a low and quick growing sort. Plant two rows ten inches apart and they support each other without help. They mature in about two months so if you plant in midsummer it is easy to get a fall crop.

To have vine-ripened *tomatoes* all winter is easily possible even without a greenhouse, if you have indoor space and plenty of southern sun. To have fruit for Christmas, start plants in midsummer and cross-pollenate the blossoms with a tiny brush. The small red or yellow, pear, cherry and plum tomatoes have been found by U. S. D. A. tests to contain 4 times the vitamin C content of ordinary varieties.

Beans of many sorts are dried for winter use; we mention only three special kinds—the *fava, broad or horse bean,* the *edible soy bean* and the *mung bean.* Broad is the best name for this larger-than-lima bean with its eye at one end. It is hardy too and must be planted early in spring with the pea crop so as to mature before summer heat. It has strong upright stems perhaps two feet high, but in spite of its sturdy look, it is susceptible to insect pests during early growth. Bio-Dynamic spray 501 used when the plant has its second pair of leaves will speed growth quickly beyond the dangerous period. It may be harvested and eaten green like the lima or dried as a winter shell bean. Like the soy bean, it is widely used in Asia and Europe and for concentrated food value, we miss out by not eating more of both of these.

There is a difference between the kind of soy bean used as a field crop and the edible garden variety. Be sure to buy the latter and if you have trouble getting them started one year, save what seeds you can for the next. Bought seeds seem to be inferior. One advantage in raising your own soy beans is that you can harvest some green, when the beans are full size but before pods turn brown. They have a different flavor and cook more quickly than the dried bean but do not keep—unless frozen. To make them slip easily out of the shell, immerse in boiling

water for 2 minutes and drain. Soy beans contain three times as much protein as other beans, and no starch, so are a true meat substitute. Dried they need long cooking but the time may be shortened by two hours if they are first soaked in what liquid they will absorb and then frozen. They have a delicate flavor all their own and are good with just butter, salt and pepper; but they may be combined with many other foods. In cooking add salt, fat or molasses only at the end, as these tend to toughen and lengthen cooking time. Coarsely ground as soy grits, they have many uses. (See Adelle Davis's "Let's Cook It Right" for good soy suggestions.)

Mung beans you have probably eaten without recognition if you are fond of Chinese food. They are the ones used for bean sprouts. Smaller than a pea, roundish and olive green, the mung bean is as easy to grow as any other bean, produces prolifically and keeps well if harvested when dry but before the pod pops open and shoots the beans out. To sprout them is very simple. Just provide constant moisture (but not standing water) and warmth, excluding light but not air. An ordinary flower pot will do the trick and it takes only a few days. Start with fewer beans than you think you need, as they swell and the sprouts expand. Use as soon as large enough (they do not keep) and cook by steaming only long enough to heat through—about four minutes. When you find how easy this is to do, perhaps you'll try sprouting other seeds—*other beans,* especially soy, *peas, lentils, wheat, alfalfa, rye, corn, millet* and *sunflower seeds* are all good. Vitamin content soars as the sprouts lengthen, especially vitamins B and C which are many times greater, making all these sprouts a particularly valuable winter food.

This article aims only to be suggestive. You will find many other plants, both wild and cultivated, which you can add to this list. Only a few specifically Bio-Dynamic directions have been given. What we mean by saying that food should be "Raised Bio-Dynamically" will have to wait for another article, but that will be basic to all that has been said here.

Meanwhile please notice that canning has not been mentioned, freezing only incidentally, and no greenhouse has been recommended. All these have their place, but here selection has been made of foods that can be grown and kept in the most simple ways and with the minimum of equipment. Good food is very important, but after all it is only a means to the end that we

"may have life and that more abundantly", so the less time and effort required for it the better. For equipment one really needs cold frame space. The standard frames 3 by 6 feet are easy to get, but if you use a plastic instead of glass for cover, they are much lighter to handle. Besides the plastic cover, I like two others, one for shade and one for bird and rabbit protection, the latter of one inch mesh chicken wire on a frame. The plastic frames are used only in early spring, and over winter with an outer cover, but the cold frame is valuable for all year round use as a protected bed. Shade may be had with a lath frame raised high enough and extended beyond the frame so that you can work under it, or you may spread burlap or branches or weeds on top of the wire mesh. There are government bulletins on cold frame construction. Send to U. S. Government Printing Office, Washington, D. C., for their price lists of bulletins.

Flats are essential, as many as you can accommodate in the house and the cold frame. I like small flats with an inside measurement of 6″ by 24″ by 2½″. They are lighter to handle and enable one to keep separate the kinds of seeds which need different treatment, such as tomatos and cabbage, peppers and leeks. Seedlings germinate and grow at varying rates and one learns by experience to group those which have similar rhythms.

A cool cellar with a dirt floor and preferably no machinery in it, is almost essential. If you are building a house, be sure to plan for this. Also in building if you have a south exposure on or near the ground level, you can have a simple indoor garden for winter by building the outer wall of cinder blocks from the frost line up to about 2 feet above the ground floor level, where window space should begin. Leaving about 32 inches of space inside, build another similar wall of the same height and as long as the possible window space. Before setting the windows, throw in a good bed of stones and then soil with 6 inches or more of good top soil mixed with well-decayed compost nearly up to the top of the walls and base of the windows. This is your indoor garden. It has no bottom but direct connection with the earth, so there is no drainage problem. You will find such a garden enjoyable as well as useful during winter months when the outdoor garden is asleep. Gay blossoms, luscious greens and dainty, fragrant herbs against a snowy landscape are cheerful winter company.

NOTES ON THE FARM CONFERENCE

PETER ESCHER AND HELEN PHILBRICK

Last September another conference, especially planned for farmers, was held at Golden Acres Farm, Newtown, Pa. What follows here is a kind of "organic composting" of the notes and recollections of two of the active B.D. workers who took part in these sessions.

The first hour of a conference is generally not quite settled. There is a ripple of unrest until everyone gets down to business. This agricultural conference was even more slow in getting started than most. However, *the cause this time was not man* but the floods that had wrought their havoc in the surrounding countryside and in a number of cases delayed the arrivals of the conference participants. When I, myself, reached the Delaware at Washington's Crossing a sign, "Bridge Out", greeted me.

I had to make a long detour up the Delaware and was given a first-hand occasion for seeing what nature can do: in short order twisting rails as youngsters play with wire, bending sturdy block signals on the railway, washing embankments away as if they didn't belong there — and maybe they didn't at that. Along the sides of the Valley, about 20 feet above the river bed, was a line, as straight as a die, of grey clay deposited on leaf and tree. The river wanted to say: Look, this far I went. But that's child's play, haven't even gotten started.

Shortly before starting out I had been reading a duly accredited textbook on agricultural fertilizers, their use and application. The learned professor explained carefully that a soil analysis shows that you need so much NPK in order to get such and such a crop. Or you feed an animal so much of the different feedstuffs and you achieve so much growth, so and so many B.T.U.s are needed by the animal for its body heat.

And along comes the Delaware and washes down our highways and railroads. And where — may I ask — is the Professor's equation? Are we not toying with nature in a way that was not intended? All our sources of information in press and radio are geared to minimize nature and its phenomena. Weather reports are given to inform us whether it is comfortable outdoors and let us know about driving conditions. But it would appear that rather than trying to understand the phenomena, every effort is made toward trying to suppress them in men's minds. How admirably have we succeeded in NOT understanding *nature.*

It was with such things in the background of my thinking that I arrived, late, at the sessions.

The Conference had opened with a discussion concerning the biological control of insect pests and rodents. It appears that they do not like the smell of their own ashes or the smell of their own debris. Slugs have been collected and left in tin cans to rot in their own juice. The diluted juice was then sprayed over an area. People who have tried this report that the slugs will not move into that area. Experiments along similar lines have been made with ants and were described as successful.

A similar test was made with weevils in flour. To a box containing a little flour, 20 weevils were added. These crawled all over the box. The ashes of 2 or 3 weevils were then added to one side of the box, with the result that the 20 weevils promptly went over to the farther corner. Finally ashes of weevil were sprinkled all over the flour in the box, and the live weevils crowded into one side of the box.

Those reporting on experiments and experiences stated that for the ashes of insects it is best to burn them between the middle of May and the middle of June. Eggs, larvae and the whole insect can be taken. After having let them rot a bit first, make a charcoal fire to burn what is left, collect charcoal and insect ash, and spread lightly over the plant-growing area to be protected. For warm-blooded pests, the suggestion was to burn the skins of the rodents at some time between mid-November and mid-December. For weed control along these lines, take seed and root. In the case of milkweed, for instance, take seeds and roots from 5 to 10 plants, burn them thoroughly on a charcoal fire, and proceed as above. Such burning of weed materials can be done any time of the year.

These ash experiments have to be done over a period of 4 years, and the materials have to be broadcast over large areas in order to be effective.

Other sorts of biological controls also received thorough discussion. For instance there is the "milky disease" which has helped to control the Japanese Beetle, and a certain type of wasp that preys on caterpillars. In an orchard, the releasing of numbers of ladybugs and the encouraging of birds can be a good means for insect control. However, if this is to be effective, no poisonous sprays can be used, or else the birds and the helpful beetles will also be poisoned. The warning was voiced that it can happen that a year's crop may be lost until the biological

controls become effective. It was also stated at this discussion that guinea hens can be used effectively to chase away rats.

In the evening of the first conference day, Dr. Pfeiffer talked about the physical aspects of the soil.

The major limiting factor in plant growth is water. Plants can be grown in sand — if there is enough water. The roots take their nutrients out of the soil. Air is also a nutrient medium of the plant. A plant contains about 80% water (the potato as much as 90%) ; another 15% of the plant is organic matter. The remaining 5% consists of inorganic matter or minerals. As most of the water comes out of the air, 90 to 95% of the plant comes out of the air and only 5% out of the soil. By using chemical fertilizer, one feeds only the 5% coming out of the soil. By the same token, if man were fed along these lines he would have to live on salts.

Barren desert soils, after irrigation, have become some of the most fertile soils known — provided there is enough water. Soil in a good state of cultivation contains 30-50% water, with sandy soils averaging near 30% and clay soils 50%. Fifteen to twenty percent water is the lower limit for the growth of cultivated plants.

From the biological angle, carbon dioxide is the single most important fertilizer that helps to build organic matter in the plants with the help of warmth and light. Part of the carbon dioxide comes from the surrounding air in which the plant grows and part from the air in the soil in which it is rooted. The CO_2 in the soil is produced by soil organisms and by decaying organic matter. Lush and vigorous growth depend on carbon dioxide. Leafy vegetables need more CO_2 than the air supplies, and get some of it from the soil. Soil that is protected from the wind has about twice as much CO_2 as soil exposed to the wind. If an area is enclosed by windbreaks and hedgerows, you get more lush growth. Wind also has a drying effect. Growth of plants can be doubled by an increased CO_2 supply.

Dr. Pfeiffer continued by going into a detailed exposition with regard to the mineral elements in the plants. He said he would try to indicate why mineral nutrients are also needed for plant growth.

From the practical point of view there is a fundamental difference in the behavior of different types of soil. Sand is silica (SiO_2). Clay soil contains silica, aluminum oxide and often marl, while frequently it also has other minerals in it. Clay is the end product of a natural breakdown of rocks such as granite or slate schist.

The role of potassium in plant growth is the easiest to understand. It is taken up through the roots into the cells, and is essential to the process of starch formation in the plant. Corn often contains 9% starch, wheat 12%, yet there is no potassium found in the plant cell. Potassium is not a plant food but it is a contributing agent needed to enable the plant to produce starch. Minerals are often labeled as plant food. By the same token our ordinary table salt could be called a food, whereas it is a conditioner which helps us to digest.

Phosphates are needed to produce protein. Part of the phosphate is locked in the protein molecule. Only a very small amount of phosphate is needed per acre.

No plant would grow without sulphur. Lack of sulphur causes phosphate deficiencies. Phosphate is needed only at a rate of 6 to 30 lbs. per acre; the rest is wasted.

Some experiments at Beltsville show that only 2% to 10% of phosphates are utilized by the plants, while the remaining 90 to 98% are wasted and become unavailable to the plants. By proper treatment of the soil they may become available later on. A release to dairy farmers three years ago stated that it was not necessary to use 300 lbs., but only 30 lbs. per acre of phosphates. This is the first breach in the stone wall of dogmatic opinion.

Every agricultural textbook states that sulphur is an essential element, yet nobody has insisted that it be used as a fertilizer.

Nitrogen has an upper limit of 200 lbs. per acre, of which 50 lbs. are available to the plant growth while 150 lbs. are lost due to transformation of nitrogen compounds in the plant during the growing process. This leads us to the question — how efficient is the use of fertilizers? Phosphates show an efficiency of 2-10%, nitrogen 25% (though usually less), sulphur 100%.

A good soil with sufficient moisture, planted to clover or alfalfa, can, with a proper biological treatment, produce and accumulate between 80 and 200 lbs. of N in their second year. If a farmer has a nitrogen deficiency, he does not understand his soil. A nitrogen deficiency exists only if we leave it to man to solve the problem. The nitrogen supply is the critical factor in agriculture, yet its maintenance is also in reality the easiest problem to solve. If we work right, biologically, we should never have a nitrogen deficiency.

Calcium is necessary to neutralize the soil, but in excess it makes the soil sterile. Of the plant, about 0.2% is calcium. About the same proportion should be sufficient in the soil. Calcium is absent in sand and granite.

In Holland there was a certain farm with a very acid pasture soil. The agricultural experts advised a ton of lime per acre, and the same again next year. Yet the soil remained acid. Where did the lime go? It showed up in the soil profile. Lime migrates downward at a rate of 1″ per year, making a kind of soil calendar.

Calcium in certain amounts is necessary for a plant in connection with the fine film of wax that makes an outer protective covering. Weeds have this protective cover, but we take it away from cultivated plants by *over*-fertilizing with calcium and potassium.

Whenever lime is needed, we recommend dolomitic lime because of its magnesium content. Magnesium, in small amounts, is important in connection with the development of chlorophyl.

With reference to the migration downward of overdoses of lime, it is of interest that plant roots will not reach into layers of fertilizer. It has lately been repeatedly found that grass refuses to grow on golf courses where so much fertilizer has been applied over a period of years that small lumps of it are visible to the naked eye when one digs down.

Iron, in high dilutions, is important as a catalyst for copper.

Boron, needed for the growth of clover and alfalfa, is deficient if present in a quantity smaller than 2 parts per million, and is toxic if more than 30 ppm are present.

Molybdenum is needed in a soil in as small a dilution as 0.001 ppm. As one acre contains 2,000,000 pounds of soil in the area of cultivation, 0.002 lb. of molybdenum is needed per acre. It helps in the assimilation of nitrogen. Liming can nullify the trace elements and, among other things, we will have a nitrogen deficiency.

Zinc is needed for raising citrus fruit, and also for dairy cows.

The soil, or rather what is in it, is like a capital reserve, or money in the bank. Every good business needs a reserve. We can withdraw some of it, but we also have to build it up. Organic matter and humus are that reserve in the soil. Humus is not organic matter which decays, it is *digested* organic matter. The role of humus is not merely that of a storehouse, but lies in its regulating capacity. In a certain field on Dr. Pfeiffer's farm in Chester (where, as we know, much attention is paid to humus), there is a potassium deficiency. Yet there is no potassium deficiency in the corn grown on that field.

There is another farm, where the fields have 2,000 pounds of total phosphate per acre, yet there is a phosphate deficiency. That farmer has forgotten how to handle his soil. Such deficiencies disappear if the organic matter content is above 2%.

A soil with 2% organic matter can build up a reserve. If a soil has 1.5% organic matter or less the situation is like that of a man continually withdrawing from his bank balance without depositing. More and more American soils are approaching, and sinking below, the line of 1.5% organic matter that represents the critical level. In business, that would be the point where the liquid assets have been dissipated. Organic matter must be added to the soil or we are going down a one-way street to the poorhouse. Below the 1.5% organic matter level the soil is in a wasting condition. The fertilizer industry understands this principle. Even magazine advertisements by the commercial fertilizer interests say that organic matter is a *must* to the farmer. Five years ago no one believed this, now there is no question about it.

The two limiting factors in plant growth are water and organic matter.

Our basic object at present is to produce humus. Humus is not just organic matter plowed under. It is that part of organic matter which is digested by the bacteria in the soil. These bacteria need to be fed in order to stimulate them and enable them to work for us. If the soil life is stimulated, the organic matter content is increased.

Organic matter can hold up to twice its own weight in moisture. So in case of a summer dry spell or an actual drought, plants in a healthy soil can get along for 3 to 6 weeks without additional moisture. Furthermore, a healthy soil can absorb a heavy rainfall while a run-down soil will wash out.

Also, the roots in a healthy soil grow differently than in a run-down soil. There are more feeder roots and hair roots. Mineral fertilizer in a soil tends to make a plant grow relatively few roots. Such a small root system is not very resistant in a drought.

There were a number of question periods at the conference. These were of great value and interest to those present.

At one of these sessions, the problem of irrigation was broached. On Golden Acres, the Stubers' farm, there are about 25 irrigated acres. Mr. Stuber said that during July and August he would have liked to have had about 200 acres that could have been irrigated. On the area that is so treated, the water is first

pumped from a well into a pond, where it has a chance to warm up before being used.

For irrigated pastures, it has been found that shallow-rooting grasses and plants are preferable, as the water does not penetrate to the deep-growing roots.

The farmers present were asked whether any had had trouble with cattle diarrhea on irrigated pastures. One reported that he did have some trouble on a pasture that had been treated with commercial fertilizer.

At the conclusion of the conference, Mr. Mahle, speaking for everyone present, voiced the sincere thanks and appreciation of all the guests to Mr. and Mrs. Stuber and their helpers for all that had been done for them during the past days. He extended a special tribute to Mrs. Stuber for the work she had put in, in the preparations for the meeting and the day-to-day functioning of her expanded "household".

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